

REMARKS

Claims 1, 4-12, and 17-26 are pending in the application. Claims 1 and 17-19 have been amended and claims 2-3 and 13-16 have been cancelled. Further, claims 4-12 have been withdrawn pursuant to a restriction requirement. Claims 20-26 are newly added in order that the applicants can more fully claim the subject matter of their invention. No new matter has been added by the amendment.

Claim Objection

Claim 19 has been objected to under 35 C.F.R. 1.75(c) for being in improper dependent form by failing to further limit the subject matter of the claim from which it depends. The objection is believed addressed by the amendment of claim 19 changing its dependency from claim 17 to claim 18.

Rejection Under 35 U.S.C. § 103(a)

Claims 1 and 17-19 stand rejected over Okinaka (U.S. Patent 4,349,411). This rejection is believed overcome in view of the amendment of claims 1 and 18 together with the following remarks.

Claim 1, as amended, recites an aqueous etching agent for anisotropically etching copper. The etching agent includes potassium hydrogen peroxomonosulfate having a concentration of about 0.08 to about 2.0 mol/l and acetic acid. (The applicants have converted the claimed concentration range back into the originally recited units to maintain consistence with their specification.) The claimed concentration range provides an amount of potassium hydrogen peroxomonosulfate that is effective in anisotropically etching the copper. The applicants point out on page 5 of their specification that smaller concentrations result in line-width narrowing, and at higher concentrations, the etch becomes difficult to control.

In the applicants' claimed etching agent, the acetic acid functions in conjunction with the potassium hydrogen peroxomonosulfate to wet the surface of the copper during the etch. The wetting action acetic acid cooperates with the etching action of potassium hydrogen peroxomonosulfate to achieve anisotropic copper etching. The applicants respectfully assert that their claimed aqueous etching agent is not suggested or disclosed by Okinaka.

As set forth by the applicants in their specification, their invention overcomes the undercutting phenomena obtained with wet copper etching solutions of the prior art. In FIG. 10C, the applicants show the typical undercut of a mask pattern using prior art etching methods. As described by the applicants' on pages 3 and 4 of their specification, the lateral etching of the copper experienced with prior art etch solutions narrows the copper line-width relative to the overlying mask pattern. Further, because the lateral etching takes place at a relatively high etch rate, process control becomes very difficult. The ability of an etching process to faithfully reproduce the dimensions of the mask pattern is essential for high quality device fabrication.

An advantage of the claimed etching agent is the uniform etch rate of copper layers. Here the potassium hydrogen peroxomonosulfate acts as the etching agent and the acetic acid "wets" the copper to assist in the etching. The present invention overcomes the limitations of the prior art by providing a copper etching agent that etches the copper anisotropically. The applicants illustrate the copper line profile obtained by their anisotropic etching solution in FIG. 7. As illustrated, the copper etch profile of their preferred etching agent shows substantially vertical sidewalls. Further, the line-width is wider than that observed by prior art etching solutions indicating true reproduction of the overlying mask dimensions.

Claim 17 is believed to be allowable in view of the amendment and remarks pertaining to claim1 from which it depends.

Claim 18, as amended, recites an etching agent for anisotropically etching a copper layer having an overlying mask pattern. The etching agent etches the copper layer at an approximately uniform rate throughout the etching process, such that edges of the copper layer are substantially continuous with corresponding edges of the mask pattern. The applicants respectfully assert that Okinaka does not suggest or disclose the claimed etching agent.

In contrast to the applicants' invention, Okinaka discloses an etchant for etching aluminum-copper alloys. (Okinaka, Col. 1, ll. 65-68, Col. 2, ll. 1-13). The etchant includes a monopersulfate oxidizing agent and a complexing agent for copper ions. While Okinaka discloses that saturation amounts for the monopersulfate oxidizing agent may be satisfactory, Okinaka further teaches that a fairly low concentration is preferred.

(Okinaka, Col. 2, ll. 45-48). This is different than the etching agent of either claim 1 or claim 18 at least because the etching agent recited in these claims includes a higher concentration than that taught by Okinaka to maintain the uniform etching rate throughout the etching process. Since Okinaka teaches that the use of higher concentrations is wasteful of material, Okinaka teaches away from the concentrations necessary for the uniform etching of copper throughout the etching process. (Okinaka, Col. 2, ll. 48-50).

Okinaka also teaches the use of an amine complexing agent in order to prevent the precipitation of the copper ions from solution. (Okinaka, Col. 2, ll. 53-68, Col. 3, ll. 1-3). The amine complexing agents disclosed by Okinaka include nitrogen. In contrast to Okinaka, applicants claim an etching agent that includes acetic acid. Acetic acid is not an amine and applicants respectfully point out that, while glycine can be derived from acetic acid, the amine compounds do not have the same chemical reactivity as acetic acid since they are nitrogen bearing compounds. Further, the ammonia anion in glycine is structurally different from the hydrogen atom that it replaces in the acetic acid molecule leading to different physical properties. Thus, there is no inherent teaching within Okinaka that acetic acid could replace an amine since the different physical and chemical properties will lead to different reactivity.

Although, Okinaka teaches that a surfactant is used as a “wetting” agent to remove the hydrogen bubbles so that an even etching action is attained, Okinaka does not suggest or disclose that acetic acid might be used in combination with potassium hydrogen peroxomonosulfate to anisotropically etch copper.

Claim 19 is believed to be allowable in view of the amendment and remarks pertaining to claim 1 from which it depends.

New Claims

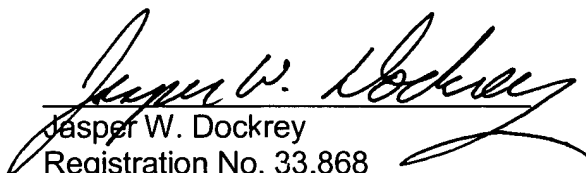
Claims 20-26 recite additional features of the applicants' invention. Claim 20 recites an aqueous etching solution for anisotropically etching a copper layer having a mask pattern thereon. The solution includes potassium hydrogen peroxomonosulfate and acetic acid. The acetic acid continuously wets exposed surfaces of the copper layer and the potassium hydrogen peroxomonosulfate uniformly etches the copper layer. The copper layer is etched to substantially the same dimensions as the mask

pattern. The applicants respectfully assert that claim 20 is not suggested or disclosed by the cited prior art of record.

Claims 21-26 recite further aspects of the aqueous etching agent recited in claim 20. These claims are believed allowable cited prior art of record.

The applicants have made a novel and non-obvious contribution to the art of aqueous etching chemistry for anisotropic thin film processing. The claims at issue are believed to distinguish over the cited reference and to be in condition for allowance. Accordingly, such allowance is now earnestly requested.

Respectfully submitted,


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